ACCELERATOR DIVISION DEPARTMENTAL PROCEDURE

AD/MECHANICAL SUPPORT

ADDP-ME-0705

ANTIPROTON SOURCE LITHIUM LENS FILL PROCEDURE

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REVIEW AND CONCURRENCE RECORD

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1.0 PURPOSE AND SCOPE

The purpose of this procedure is to establish the techniques and outline the potential hazards associated with filling the Antiproton Source lithium lens assembly. This procedure is applicable to both the lithium collection lens and the lithium proton lens, with only minor dimensional variations in the hardware used for the fill operation. Special preparations and precautions are oulined to minimize potential hazards associated with casting lithium in the molten state. The mechanical, electrical, and physical design parameters are not described in this note. Also not discussed are temperature compensation and calibration of the lens body strain gage and pressure transducer. Only activities relevant to introducing lithium metal into the core of the lens are addressed. The delineated tasks assume a new lens has been correctly fabricated and awaits lithium fill.

2.0 RESPONSIBILITIES

At the request of the Antiproton Source Department, Mechanical Support Department personnel will fabricate the lithium lens assembly, coordinate pre-fill planning tasks and lens inspection, and perform the lithium fill. The Antiproton Source Department Head or his designee shall be present during the fill operation.

3.0 SUPPORTING DOCUMENTS

3.1 DRAWING REFERENCES

The following drawings may be referenced should questions concerning hardware configuration arise:

3.1.1 Antiproton Source -

3.1.2 Antiproton Source-

3.1.3 Antiproton Source-

3.1.4 Antiproton Source-

3.1.5 Antiproton Source-

3.1.6 Antiproton Source-

3.1.7 Antiproton Source-

3.1.8 Antiproton Source-

3.2 ENGINEERING SPECIFICATION REFERENCES

3.2.1

4.0 INSTRUCTIONS

4.1 GENERAL COMMENTS

As part of the fabrication of a lithium lens, lithium is introduced into the body of the lens in the molten state and subsequently extruded to achieve a design preload of 2300 psi for the collection lens and a preload of 3100 psi for the proton lens. The objective is to introduce the lithium such that the material is extruded with a high degree of purity and absent of internal voids. The purity of the lithium is controlled during the fill as follows:

1) Lithium metal is never exposed to gaseous oxygen or nitrogen at any time
2) To prevent surface contamination, all surfaces which are to contact the liquid lithium shall be thoroughly wiped clean at least three times with ethyl alcohol and rinsed three times with deionized water. All cleaned parts shall be subsequently dried using a heat gun for 15 minutes.
3) Prior to fill, All parts used in the fill operation shall be outgassed in a vacuum at a temperature of 200^{o} C for a minimum of one hour.
4) The task of melting the cylindrical lithium slug shall occur in an evacuated bellows.

Approximatly 50g of lithium metal are required to fill the internal volume of the collection lens (bore dimensions: 15 cm length by 2 cm diameter), while 2g are required to fill the proton lens (bore dimensions: 8 cm length by 6 mm diameter). Battery grade lithium (92.6% Li-7, 7.4% Li-6) is used in lens fabrication.

General comments about Li from MSDS here.....

4.2 PREPARATION AND LOADING OF LITHIUM BELLOWS

The preparation and loading of bellows is identical for both the collection and proton lens.

4.2.1 CLEANING AND OUTGASSING THE BELLOWS

a. Plastic gloves shall be worn when handling the bellows. Clean the external surface of the bellows, bellows head, and compression cap with ethanol.
b. Pour ethanol into the bellows (fill to about 1-2 inches). Thread the head and cap on and shake vigorously. Remove the head and cap and pour the ethanol into a plastic container with a cap for waste disposal. Repeat this step two more times.
c. Replace the head and cap and clean the outside of all three pieces with ethanol.
d. Clean the following with ethanol: the glove box table, rear bellows plate, bellows vacuum fixture, and the bellows fixture.

e. Place the bellows (with head and cap secured) into the bellows fixture. The fixture has the surface of one end machined. The bellows head should be oriented toward the machined surface of the fixture.
f. Attach the rear bellows plate to the fixture end opposite the bellows head and secure with three screws and a center bolt. Adjust the three screws such that the plate lies flat.

g. Attach the vacuum fixture to the head-end of the bellows. Join the fixture end and the glove box vacuum port with a vacuum hose and clamps. The glove box port should be connected to the Trivac pump.
h. Place the fixture assembly on two insulating bricks in the glove box.
i. The bellows fixture includes four heaters in parallel and a pair of thermocouples. Plug the thermocouples into sockets 7 and 8 on the glove box panel (order is not significant). Plug the heater wires into the red/white power line. Plug the oxygen monitor into the first pin connector (marked "O").
j. Close and fasten the glove box cover and open the vacuum valve to pull a vacuum in the bellows.
k. Purge the glove box with Argon gas. After 5 minutes, power up the heaters and heat the bellows to 200º C and hold for 30 minutes. During this time, keep pumping on the vacuum and maintain the argon atmosphere in the glove box below 2% oxygen.
l. After 30 minutes, turn off the heaters and allow the bellows to cool to a temperature below 35º C. Open the glove box cover.

4.2.2 SECURING LITH IUM IN THE BELLOWS

a. Place the following items in the glove box: two 7/8" wrenches, a 7/16" wrench, screwdriver, two dowel rods (to tighten bellows cap), electrical tape, cleaned forceps, cleaned scissors, 1/2" compression cap for bellows, cleaned razor blade knife, and a 235g lithium cylinder (vendor packaged in a sealed aluminum foil package filled with argon gas). Remove the insulating bricks, and disconnect the thermocouple and heater connections.
b. Important: Before lithium is inserted in the bellows, the electron beam welder shall be warmed up, maintain welding vacuum, and shall have been beam tested at full power (beam welder: x4834). This shall be done to minimize exposure of the unwelded bellows to atmosphere.
c. Close and secure the glove box cover and purge with argon gas.
d. When the glove box atmosphere is below 100 ppm oxygen, remove the vacuum hose connection from the bellows, remove the bellows from the heater fixture, and remove the bellows head.

e. Using the rubber gloves penetrating the glovebox, feel the outside of the lithium package to locate the end of the lithium slug which has no center hole.
f. Cut open the non-hole end of the lithium package and transfer the lithium into the bellows directly from the package without touching the lithium cylinder.
g. Secure the bellows head; use care to ensure that rod on the inside of the head registers into the hole in the lithium cylinder. Tighten the bellows head using the two dowel rods.
h. Thread the compression cap on the head and wrap electrical tape around the head to bellows joint to preserve the argon environment inside the bellows.
i. Immediately transport the bellows to the beam welder.
j. At the beam welder site, remove the electrical tape and clean the joint with ethanol and an air can. Scribe a mark across the joint as a reference for setting the welding chamber rotary table speed.
k. The first beam welding pass on the head/bellows joint shall be made at relatively light power using the following parameters: voltage=110 kV, current=4 mA, weld time=38 sec/revolution (single pass).

l. The second beam welding pass shall be a full penetration weld using the following parameters: voltage=150kV, current= 20 mA, weld time= 38 sec/revolution (single pass). Allow the bellows to cool for 10 minutes before removing from vacuum chamber.
m. Remove any weld balls from the convolutions of the bellows and machine the weld flush with the head to ensure that the bellows will fit into the ram.

4.3 PRE-FILL LENS ASSEMBLY AND GLOVE BOX PREPARATION

The pre-fill preparation of the collection and proton lens is identical with the exception of the strain gages and pressure transducer used by each assembly. The application and calibration of these devices is covered in ES-xx-xxxxxxx for the collection lens and ES-xx-xxxxxxx for the proton lens. Additional items covered in the noted Engineering Specifications are procedures for pressure checking and outgassing the lens assembly.

4.3.1 INSTALL LENS BODY HEATERS

a. The collection lens body uses four cylindrical 600 watt heaters during the fill procedure. Two heaters are positioned on each end of the body and secured with band clamps. Use care to avoid contact with the thermocouple, pressure transducer, or strain gage wires. The heaters must be positioned such that the filling arm surface is accessible.
b. The proton lens body uses two 600 watt and one 1000 watt cylindrical heaters during the fill procedure. One 600 watt heater is positioned over each end of the lens body and the 1000W heater is positioned over the center of the lens body and

secured with band clamps. Use care to avoid contact with the thermocouple or strain gage wires. The heaters must be positioned such that the filling arm surface is accessible.

4.3.2 MOUNT THE FILLING ARM

a. The filling arm is used to introduce lithium into the lens body and serves as the main channel between the bellows/ram assembly and the lens. Each new fill arm placed into service shall have been successfully hydrostatically tested to 10,000 psi at ambient conditions.
b. Wearing industrial rubber gloves and protective face shielding, etch the fill arm in a weak (5%) solution of nitric acid for 30 seconds and rinse thoroughly with deionized water.
c. Wear rubber gloves for the following fill arm mounting steps to avoid contaminating the parts with surface oils.
d. Clean the following with ethanol and blow clean with an air can: the fill arm surfaces on the lens body, the fill arm mounting surfaces, and the fill arm nickel seals.
e. Mount the fill arm to the lens body with the nickel seals placed at the mating surface of the lens body to fill arm. The fill arm should be oriented such that when the lens is viewed from the cooling tube side with the seal mounting surface at the 12 o'clock position, the fill arm projects to the right. Secure the arm with four grade eight 1/4-20 bolts sized for full thread engagement into the lens body.

f. With the lens secured on the carrying fixture, cap the free end of the fill arm (i.e., end to be attached to the bellows) and attach the all-metal valve to the top of the arm. Connect the valve to the vacuum pump port in the glove box using convoluted stainless hose.
g. Pump down the lens assembly using a leak cart with a nitrogen cold trap and leak check the fill arm and seals. Additionally, check the entire assembly under full helium atmosphere (bagging). The leak rate should be equal or less than 1E-06 atm•cc/sec. On a leak cart with a nominal sensitivity of 1E-10 per division, this would correspond to a maximum 10 division leak on the 1000X scale. Should the leak rate exceed the specified amount, the assembly shall be checked to determine the location(s) of the largest leak source(s) and reworked to provide an acceptable leak rate.

4.3.3 INSTALL ARM HEATERS, EXTERNAL THERMOCOUPLES, AND GENERAL INSTRUMENTATION CHECK

a. Secure two thermocouple leads under a stainless hose clamp on the upstream housing positioned just downstream of the lens heater.
b. Secure three 50 watt heaters to the fill arm using stainless band clamps. Position the heaters such that one heater is fastened to the top of the arm between the two fill ports, with the remaining two heaters fastened to the fill arm inlet.

c. Fasten two thermocouple leads on either side of the fill arm at the "T" intersection using the 10-32 tapped holes in the arm.
d. Connect the lens body heaters at this time. The collection lens body heaters are connected in parallel for each pair of housing heaters and subsequently in series between the housings. The resistance on the input leads should be about 24 ? . Connect the proton lens heaters such that the two 600W housing heaters are connected in parallel and subsequently connected in series with the 1000W heater.
e. Connect the three arm heaters in parallel. The resistance between the input leads should be about 96? .

4.3.4 PRESSURE TEST AND GAGE CALIBRATION

a. As a preliminary check, check the strain gage and pressure transducer resistance. The values should measure within the limits outlined in ES-xx-xxxxxx and ES-xx-xxxxxx. Also, check the connections in the glove box and data logger by plugging the connectors into the glove box ports (marked "S" for strain gage and "T" for pressure transducer, and standard type J thermocouple connections) and checking the readouts to ensure the signals are transmitted correctly.
b. Attach a length of 3/8" dia. x 0.035" wall titanium tubing to the free end of the fill arm and attach the other end to the glovebox feedthrough on the main panel. Use swagelock double ferrule stainless fittings on each end.
c. Close the glove box and connect an argon bottle to the appropriate glovebox feedthrough connection attached to the lens fill arm. The bottle should be connected using the same type of tubing and fittings as outlined in (b). Attached between the bottle and glovebox should be a 1000 psi gage and an 800 psi ASME coded pressure relief valve.

d. Slowly bring the argon pressure up from 0 to 600 psi and back to 0 in 100 psi increments as indicated on the pressure gage attached to the argon bottle. Record the strain gage and pressure transducer (for collection lens) readings for use in gage and transducer linearization.
e. After the test is completed, open the glovebox and replace the blanking cap for the pipe connection on the fill arm.

4.3.5 OUTGASSING AND TEMPERATURE CALIBRATION

a.

4.4 LENS FILL PROCEDURE

Main Points for Lens Fill

1) Check He lines at ambient to make sure flow path is open

2) Check oil pressure transducer readback at ambient; readback and pressure gage should agree

3) Check all thermocouples to make sure they are secure, operating properly, and read back correctly. The thermocouples should be set up such that the thermocouple near the band heater is used for that particular band heater's temperature controller.

4) Check the lithium catcher used in the vaccum line to make sure it is free of obstructions. Make sure the vacuum valve is open and all vacuum lines are clear such that the lens is thoroughly pumped down during the heat up cycle prior to fill. Also make sure that hydralic pump valve is open during heat up. During heatup prior to filling the lens, the strain gage and pressure transducer readbacks should not deviate more than about ±300 psi from the 0 reference of pressurization and outgassing measurements.
IMPORTANT: Perform temperature ramps slowly at 25^{o} C intervals (total ramp to 200^{o} C should take place over a 90-105 min. interval, i.e. about 13 to 15 minutes per 25^{o} C ramp). Old procdure (up to lens 19) ramped to 200^{o} C in one hour.

5) When lithium has melted, close the vacuum valve. Evacuate the oil line with the roughing pump and pump up the hydraulic ram such that the oil pressure is at about 500-1000 psi to introduce lithium into the lens. Monitor the strain gage and pressure transducer to make sure that the lithium pressure does not exceed about 300 psi (@ the fill temperature of about 210^{o} C).

6) Turn off the lens heater and allow some modest flow of helium to flow through the septum to cool the lithium.

7) When the lithium is solid, allow more helium to flow through the lens and pump up the pressure to achievepreload per Appendix A. Start this process at about 160^{o} C and balance the lithium preload with the hydraulic pump until reaching room temperature. When the lens has reached about 70^{o} C, turn off the arm heaters.

8) When the lens body has reached 30^{o} C, turn off the ram and head heaters and discontinue the helium purge.

5.0 CONTROLLED COPY DISTRIBUTION

5.0.1 Reference Appendix A. The Mechanical Support Department Head is responsible for approving Appendix revisions.

APPROVED_____ DATE_____
Mechanical Support Dept. Head

APPENDIX A: Controlled Copy Distribution List

Controlled Copy No.	Recipient
1	Mechanical Support Dept. Head Mike May
2	Antiproton Source Dept. Head
3	AD ES&H Dept. Head Howard Casebolt
4	Responsible Engineer Kris Anderson